LECTURE

ON THE

Subject of the Levees,

READ BEFORE THE

New Orleans Academy of Sciences,

By M. JEFF. THOMPSON,

JANUARY 16, 1872.

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Mr. President and Fellows of the Academy of Sciences:

The profession of civil engineering, upon which it has become my duty, as Fellow of this Academy, to prepare an article, presents so vast a field from which to select a subject to write upon that I have concluded to devote the time allotted me to an exposition and defense of the levee system that has been adopted in this State.

There can be no subject of more interest or vital importance to the people of Louisiana than that of protection from overflow; and whether it is better or cheaper to control the floods of the rivers with "levees," or to disperse them by a system of "outlets," or reduce them by an accelerated current produced by "cut-offs" (each of which have plausibility and able advocates), will be subjects discussed.

Were the Mississippi river like the Nile, which runs from the South toward the North and brings its floods between harvest and seed time to enrich the lands for the next season's crops, then we could change our staples to something that would be profitable under such circumstances, and enjoy ourselves during the flood time, as do the people on the Nile. But with us it is otherwise, for our mighty river comes rushing down between seed time and harvest, and the crop that is most profitable to our people, being sugar, a perennial, it cannot stand an overflow. Another vast interest that the Egyptians knew not of demands protection from overflow. This is the railroad interest; for we of Louisiana cannot have grand through lines of railroads so long as they are liable to be interrupted six months in the year, with the consequent destruction of their road beds, and therefore it becomes imperative upon us to control the floods by some means, regardless of expense.

In the voluminous and able report of Generals Humphreys and Abbot, of the United States Topographical Engineers, is found a thorough analysis of this subject, and conclusions and recommendations are expressed so distinctly that it seems that the subject has been exhausted, and the most skeptical should at once adopt their views, but few have been able to read this large work (even among the *special river savans* to be found from Cairo to the Balize, who are

prepared to give advice on all subjects in connection with the Mississippi from their local knowledge), and I will draw largely from it in this article, for I could not have higher authority.

I have been personally familiar with the Mississippi and its tributaries for twenty-five years. I have been up the Platte or Nebraska river to the Rocky Mountains, and have seen the clear and sparkling sweet water as it came, apparently, across the "divide," through the South Pass, to bring its waters to the Gulf of Mexico and the Atlantic, in preference to the shorter route to the Pacific, through the Gulf of California; and from the foot hills of the mountains down to the Gulf the river bears a general character in its turbid, ever restless flow, and its cormorant-like proclivity to devour everything in its way—the prairie, the forests and the fields, and even the very rock itself where it opposes its passage.

After passing the Grand Chain above Cairo, the river enters a wider valley, and in some respects changes, but the same tearing down and building up, changing of bed and direction, goes on on a grander scale, but not so rapidly as in the valley of the Missouri. I suppose it is known to all that the Mississippi above the mouth of the Missouri is in no respect similar to the Missouri; therefore, I speak of the Missouri as the proper Mississippi.

The valley of the Missouri, as I may call it down to the Grand Chain is wearing out and sinking down with the abrasion of the waters, as is evidenced by the water slopes from the hills or bluffs to the river bed, and as is going on in nearly all other valleys, and the immense amount of soil thus absorbed is brought down to build up the valley of the Mississippi in the delta country, and the ground on which we live is composed of the worn rocks of the canons of the Rocky Mountains, the slate, the limestone and the granite mixed with the earthy matter of the Black Hills and *mauvais terre*, and of the beautiful prairies of the northwest; and as each of the mighty tributaries have during different months, as the seasons pass north to unlock their icy fountains, or in different years as local floods may have occurred, sent down their peculiar sediments, they have formed the different colored strata, or by chemical process the different kinds of strata which we observe in our alluvium; and probably if specimens of the waters of these various rivers could be collected and experimented with by different combinations, many of the

formations not now understood could be explained. The petrifying waters from the bad lands, the white sands from the upper Mississippi, the lime from the Ohio, the iron from the Cumberland and Tennessee, the salt from the Arkansas and the alkali from the Red, may find their affinities, and form what may apparently belong to a different geological period, and probably the sediment of twenty barrels of water, *one* from as many different rivers, might solve some present mysteries in *our geological formations.*

Having mentioned the difference between the valley above and the valley below the grand chain, as being, the *one wearing down* and the other building up, I would state that the *opponents of the* levees argue that the river should have full sway and let it fill up the vast basins of the St. Francis, White and the Yazoo. Now this theory may be plausible, but who can wait the many thousand years for its accomplishment, especially when such accidents happen as the New Madrid earthquake, that dropped several counties far below the level of the river in a single night; therefore I do not propose to argue with the "NO LEVEE" theorists, but put them down on my book as visionaries, who do not belong to our age, or period, as geologists might call it, for they propose to live during the millennium, when "the lion and the lamb shall lie down together."

Next to the NO LEVEE theorists are the OUTLET theorists. I will not deny but that "outlets" have the effect they claim, for I have experienced their temporary beneficial results on a large scale in the outlets at Ashton and Grand Levee. When the river banks and great swamp reservoirs are full, then a crevasse does not immediately affect the flood in due proportion to its volume, as a slight depression increases the current above, but I agree that where the crevasses are left open as outlets and run off the tap floods as they come and prevent the filling of the swamps and river banks, then they appreciably reduce the level. But when the practical engineer estimates the damage done the country, or the greatly increased cost in regulating the outflow and leveeing the sides of these torrents to where they could do no damage, then he turns from this theory to the so much easier and less expensive plan of leveeing the main channel. The facts granted in the work of General Humphreys, on page 418, that an outlet of 100,000 cubic feet per second at or near Providence, would reduce

the flood level some five feet, has been most closely confirmed. The Ashton crevasse, which has been for several seasons some 15,000 feet wide, has performed this service, but consider the vast destruction that has been the consequence, and the many thousands of acres of veluable land that are now uncultivated.

When we remember that this crevasse is nearly three miles wide, while the river at flood level is only 3000 feet wide, those not familiar with the subject, by forgetting the depth of the river, would imagine a very large percentage of the river had left its channel; but the cross section of the river is 186,000 square feet at the level of the banks, and a one-foot rise, under ordinary circumstances, would seem to such would be but a three-inch rise below the crevasse, as three-fourths of the surface water would pass out, but the facts are that the difference above and below the crevasse is scarcely perceptible, for only 15,000 feet of section will be taken from 186,000 feet of section, and the difference below would be but eight (.08) per cent. of the one foot rise, or one inch.

A two-foot rise above the crevasse would send out 30,000 square feet cf section to 189,000 square feet, and below the water would be reduced sixteen (16) per cent., of twenty-four inches, or one-sixth of four inches.

A three-foot rise above would send out 45,000 square feet to 192,000, and would reduce the flood below twenty-three per cent. of the thirty-six inches, or about nine inches.

A four-foot rise above would send out 60,000 square feet to 195,000 of river section, and would reduce the flood below thirty per cent. of the forty-eight inches, or about sixteen inches.

A five-foot rise above would send out 75,000 square feet to 198,000 of river section, or thirty-seven per cent. of sixty inches, and reduce the flood below about twenty-two inches.

A ten-foot rise would send out (if the momentum would permit it) 150,000 square feet to but 216,000 river section, or seventy per cent. of the one hundred and twenty inches, or eighty-four inches. But see the facts:

The river was higher in Memphis in 1871 than ever before known. It was higher in New Orleans than ever before known, yet between the Ashton crevasse and near down to Red river the water did not approach high water, and was at Vicksburg seven feet below the water of 1867.

This calculation applies particularly to the Ashton crevasse, where the speed of outflow is not much greater than the current of the river, and the same water returns to the Mississippi again at Red river, but crevasses below Red river where the level of the sea is to be reached by a shorter distance than that of the river, the outflow is very rapid, increasing as the river rises, but with the same proportionate result as mentioned for the Ashton crevasse. But the Ashton crevasse is rapidly closing itself, and in a few years the water will cease to flow through, as vast volumes of sediment are being deposited over the whole area.

Before the days of levees, when the river had its natural sway, outlets were continually being made and closed by its own laws, and when a natural cut-off was made the waters would rush over the banks below until they would build them up by deposits to nearly high water mark, and in some other bend repeat the same operation until in the course of the many thousand years that this mighty river has been flowing down to the Gulf, it has torn down and built up again every foot of the alluvium possibly a dozen times or more.

It can be demonstrated that at the outlet at Bonnet Carre, which is the nearest point of the river to tide water above the city, would soon close itself, for the past season alone has left vast sand ridges and rock heaps that would retard the outflow next season, and in time build a ridge as high as the Metairie Ridge, and thus create a levee up to high water mark; and, were a channel leveed in to cause the bottom to wash, it would soon fill Lake Pontchartrain with sediment and build a barrier there.

A crevasse or outlet of less than one hundred thousand cubic feet per second would do but little good below Red river, and as this water escapes only during spring floods, it is charged with its maximum amount of sediment as well as the enormous amount of drift wood, and taking the even figures of 1000 to 1 in weight and 2000 to 1 in bulk, as the average sediment carried during spring floods, we would have the following facts and figures: 100,000 cubic feet per second would deposit 6000 pounds or 50 cubic feet; 6,000,000 cubic feet per minute would deposit 360,000 pounds or 3000 cubic feet; 360,000,000 cubic feet per hour would deposit 21,600,000 pounds or 180,000 cubic feet, or per day would deposit

160,000 cubic yards, per month 4,800,000, per season of three months 14,400,000 cubic yards. Now when it is remembered that this enormous amount of material is deposited on a surface that requires only ten to twenty feet to be filled to the high water level, it can be seen how rapid the closing would be, and it can not be compared at all to the mouth of the river, where the same principle is being carried out, for the Gulf of Mexico will not do to compare with Lake Pontchartrain or the Lafourche swamps in figures, though the growing out of the mouths and the constant "bar" formations and changes of channels give evidence that the same law—of nature—is at work; so my conclusions are that while outlets may be temporarily beneficial, they are more costly than the levee system, and therefore not to be adopted.

The next in rank as theorists on the subject of the Mississippi protection, are the "cut-off" advocates.

I grant that were it possible to shorten the river, the increased speed of the current would drain off the floods more rapidly, and prevent their rising to so great a height; but the exceedingly enormous cost to maintain such a condition, and the injury to commerce would so far overbalance the cost of the levees, that I doubt if any practical engineer ever advocated the attempt.

Without most extravagant expenditures it would be impossible to maintain the shortening of the river in any one locality, and when sufficient bends should be cut off to lower the flood to any appreciable amount, nearly the whole river would have to be revetted at a cost of several hundreds of thousands of dollars for each mile.

The Missouri runs down a plane of ten inches per mile from Souix City to St. Louis, and the Ohio, below the falls, on a plane of three inches per mile. From the Ohio to the Arkansas, we have a slope of six inches per mile. From the Arkansas to the Red, four inches per mile, and from the Red, two and a half inches per mile, down to the Gulf.

Now were it even possible to make the cut-offs in the great bends, there are so few places at the present time where to make them, that they combined could make but a few feet difference in their level in these localities. If the vast army of General Grant could not make a cut-off at Vicksburg, how useless to attempt it by ordinary resources. The ditch has been dug at Waterproof for several years, and yet the

river refuses to go that route. These are the only two bends now in Louisiana—the Vicksburg and Waterproof—where even the cut-off advocates think it practical, for the Terrapin Neck and Palmyra Bend cut-offs were made in 1867.

Grant that these two cut-offs could be made—and the river maintained at its shortened distance—we would then have a difference between 1866 and 1872 of Terrapin Neck, Vicksburg, Palmyra Bend and Waterproof, of about sixty miles between the Arkansas line and Red river. We then have the computed distance of two hundred and ninety-three miles reduced to two hundred and thirty-three miles, and as the actual fall is 77.5 feet, the slope would be four inches per mile, and while portions of this slope might be several feet below the flood level, yet where would the water have gone?

There is no possibility of making a cut-off below Red River, and upon this plane with its current of less miles per hour, we would have precipitated the floods from below the Arkansas, for of course the volume of water has to be accommodated, if it comes in five days or has ten to reach us, and while the floods above Red River would be reduced, the lower river would be gorged to overflowing.

The floods are the surplus waters from the heavens, let it fall as rain or snow, and the longer time this volume is spread over a vast extent of country the less the daily escape to the ocean by our river, and the consequent less flood where the slopes cannot be increased, as is the case from Red River to the Gulf. So to shorten the river from Cairo to Red River would necessarily largely increase the daily regimen of the river below, and drown out the delta country.

But even were it not so, and the cut-offs would reduce the flood level to the Gulf, I contend that it is practically impossible to maintain a shortened river, and that the distance by the bends of the river from the grand chain to the Gulf now approximates the same as it was five summers after that convulsion of nature which broke that chain, and let the waters of the grand lakes of the northwest find a route to the Gulf of Mexico.

The slightest experiment with water flowing through alluvium will demonstrate this fact, and I have a hundred times broken the little ponds that collect near our levees to see the course the water would take, and if my trench was straight the current would assume

curves, either by picking up or depositing sediment, or crumbling in the sides, and take a distance that would produce a current in concord with the material it ran through. The plantation ditch in buckshot land is a different thing; though even this, if not properly cleaned, will soon fill up, and then the unrestrained current will form beds similar to the crooked coolies and bayous that we find even where the land is almost level and the current imperceptible.

Steamboatmen all agree that the river is as long now as when the first steamboat ran, though since then we have had the Racourci, the Shreve, the Palmyra Bend, Terrapin Neck, Bunch's Bend, American Bend and other cut-offs, which should, according to theory, have shortened the river nearly one hundred miles between the mouths of Red river and the Arkansas since the days of steamboats; and, to my personal knowledge, the Palmyra Bend and Terrapin Neck cut-offs are fast elongating themselves, and are doing it at the expense of our levees.

Scarcely had the Terrapin Neck cut-off been made when the accelerated current began to carry away the bank above at the Hanes Harris levee, and in a very short time carried away the levee, the dwelling house and all the improvements, and from the change of direction below the cut-off it rushed on the Mississippi side of Island 102, and reacted again on the Louisiana side, and tore away that long line of levee known as the Milliken's Bend levee. The accelerated current has committed depredations above as far as the town of Providence, and the long lines of new work which we know as the Hanes Harris, Bell & Newman, Savage, Illawarra, Goodrich, Aulic, Wilton, Stamboul and Transylvania and Bass levees, have been the result, and the changes of direction of the current, which, of course, passes far above and below the cut-off, have also taken away the Milliken's Bend, Buckhorn, Duckport, Utz, Young's Point and Delta levees, until meeting the bluffs at Vicksburg, where the river seems to have reached hard material, and starts upon another plane.

But within the next plane there is another cut-off, the Palmyra Bend, and see its consequences: We have an open crevasse above this cut-off, the Diamond Bend, which will require seven hundred thousand cubic yards of earth to close, and below the cut-off the change of the bed of the river reaches to below Waterproof, and has cost the State the Point Pleasant, the Wilson, Hardtimes, Disharoon,

Bondurant, Kempe and Waterproof levees, aggregating nearly one million of cubic yards. I do not know the amount of damage done by the Racourci cut-off before the war, but I do know that nearly two million cubic yards have been built in Pointe Coupée parish since the war, and we require three hundred thousand more between New Texas and Bayou Sara.

From many practical experiments it has been determined that the amount of sediment carried by the waters of the Mississippi varies in proportion to the speed of the current, and ranges from 1-1000 to 1-2000 per cent., or one thousand gallons of water will contain one gallon of solid matter, independent of the vast volume of gravel and heavy material rolled along the bottom. It is established that water moving four miles per hour will carry heavy sand, at five miles per hour will carry gravel, at seventeen miles will carry pebbles one inch in diameter, at twenty-seven miles will carry flint as large as hen's eggs, and, therefore, it is easy to perceive how the accelerated current occasioned by thus shortening the river would soon tear down the alluvium it had been centuries in building up, unless controlled by some artificial means.

With regard to these artificial means I have had some experience, and I will simply state before going further that the man who attempts to control either of the elements fire or water must not go at it half prepared, or he will surely be conquered, for the smallest leak will sometimes undermine the most costly structure, and a single spark will sometimes kindle great conflagrations.

An attempt to check the encroachments of the Mississippi, unless completely successful, will be a cause of great injury and increase of the evil attempted to be averted; for should the water get behind your works, you will have simply built an island, which may induce the whole river to pass behind it, as has often been done; and should you produce an eddy or counter current you have multiplied your evil.

It is impossible to put a small work in the right place, because the curve of the current varies with its speed, and the force that comes with the floods is generally far away from the insidious workings of the many mouths of ordinary tide, and the works should be extensive enough to cover this arc, be it three hundred or three thousand feet, before there would be any assurance of safety.

An attempt to control the Mississippi at St. Louis cost several millions of dollars, and a long term of years of labor and several complete failures. The effort was to make the river stay against the St. Louis wharf, and to do this it was necessary to check the caving of the alluvium of the American bottom on the Illinois side. After many attempts a dike stood, but its angle was such that while it forced the current against the Missouri shore, its reaction crossed again to the Bloody Island side, and formed a sand-bar where commerce needed a river. Another dike became necessary, and other breakwaters, and to keep the river against a few miles of wharf has cost several millions of dollars.

Up the Missouri river there has been a great deal of such work done, but always at considerable expense, and the cost of constant renewal or repairs.

I was one of the first successful engineers at this kind of work on the Missouri river, and built two breakwaters; at the ends the arc covered by the difference of points of concussion of the current at high and low water at St. Joseph, Missouri, some seventeen or eighteen years ago.

In these works I demonstrated to my satisfaction the futility of any one fixed plan to do such work, for each day required some new expedient, and human ingenuity is sadly taxed to make such works effective. I had to use piles, cribs, caissons, fascines, loose-brush, rock in great quantities, with the bolts, braces and ties necessary to hold this heavy mass together and prevent the water from getting behind it. I spend forty thousand dollars in gold on one of these breakwaters, which was scarcely larger than the house we are now in, but it is there, and has answered its purpose, and the property protected by it has advanced in value from a few hundreds of thousands of dollars to as many millions.

When we consider the cost of building such works on the Missouri where there is a sub-stratum of rock that underlies the river that can almost be reached by piles, we can judge of how costly a permanent work would be about Vicksburg, where the rise and fall is fifty feet, the depth at high water — feet, with no solid substratum within reach.

But still the experiment should be tried where there is valuable property to be saved, or cut-offs prevented, or very costly levees to

be protected, and I have asked the Legislature for an appropriation to make the attempt, which, if successful, will be duly reported upon to this Academy.

Having stated my objections to the foregoing plans for reducing the flood level, I will now speak of the plan of protection by levees:

In that able work of Generals Humphreys and Abbot we find a catalogue of all the important works written on hydraulics in this country and in Europe, and also a history of the levee systems of the different States and countries, and they very effectually dispose of many statements made in regard to the Po, the Rhine and the Vistula which have been made in opposition to the levee system. Once having determined to levee, the next important thing is to determine where and how to levee—that is, the proper location, dimensions, materials and manner of combining and equating them that safety may be guaranteed, and the interests of the State and the rights of the riparian proprietors be properly respected.

Under the old law where each proprietor built his own levee to his own notions there was a constant change of plan and location, and scarcely any two consecutive levees were of the same shape, height or material, and nothing but the eternal vigilance that was practical in the times of slavery kept the country from overflowing every season.

Afterwards the parishes, through their police juries and syndics, regulated the location and dimensions; then the Legislature took charge of the location and dimensions, and prescribed laws that compelled the levees to be placed at least one arpent from the river bank; then levee districts were formed, and changed, and broken up, and reformed, and rechanged, and again broken up, and thus, since the levees of Louisiana were begun, there has been constant changes, variable appropriations, and no one system has ever been adopted for the whole State until the present law was passed, and the engineers in whose hands has been placed this vast interest and interesting and important problem must give a reason for the faith that is in them, and, avoiding preconceived ideas or prejudices, must take that which is good and reject that which is bad from among all the plans and purposes that they can conceive or that may be brought before them. And it is with this idea and purpose that I have brought this matter before the New Orleans Academy of

Sciences; for, happening to be one of the engineers intrusted with this great and grave charge, I would lay our plans before you and ask such criticisms and condemnation, such approval and suggestions as the members of the Academy may see fit to make.

Under the present law, the location and dimensions, and the standard to which they shall be maintained, of all the levees in the State of Louisiana, has been left to the determination of three engineers, one to be appointed by the President of the United States, one by the Governor of Louisiana, and one by the Louisiana Levee Company—which has contracted to build for the State 15,000,000 of cubic yards of levee work and maintain the levees for twenty-one years.

While the framers of the law and the company contemplated but plain, old fashioned levee work, and make a fixed price for all alike, yet the commission of engineers have decided that the spirit of the law should be considered, and as it is safety and protection that is sought, that they will vary the old plan, and adopt and use any and all improvements that will tend to the end desired, and they will revet, interline, shore up, roll, ram and intermix with lime, and every other means that the circumstances may require.

There is a great variety of opinion in this State in regard to the cross section or proper slopes to be given to the levees, and I have much amusement with the disputes of the planters on this subject, as very few neighbors agree about it. The slope should certainly vary according to the material to be used. Above Red river, where there is so large a portion of sand in the soil, we often give a slope of five to one on one side and three to one on the other. As we come down the river the material becomes more tenacious, and were the levees built at a proper season, they could be made to stand at slopes of two to one on each side, but from the habit of building the levees so late in the season, and not giving them time to thoroughly "slack" and settle before the river stands against them, we always take more base. In railroad embankments the custom is to give slopes of one and one-half to one, as the natural slope at which *dry earth* will stand under the concussion and weight of heavy trains, but with the levees it is different, for they are, when new, but a mass of wet earth, and each particle seems independent of the others, and with great difficulty the sloughing off of

the rear of the levee is prevented. During the past season five of my levees came near breaking from this cause, where the rear slope was but two to one. The levees in Europe have the slopes of three and two to one, but where the embankments are high, it is customary to strengthen them by banquettes up to the heights at which the water may remain a long time. In Europe it is the universal custom to put the flat slope on the river side, and it has been almost universal in this country, but is a subject open to argnment, and I am myself inclined to place A flat slope in the rear of the levee, whether the front slope is flat or not. I have had no trouble with any of the scores of levees that I have built in their front slopes, except when exposed to the waves, and then a revetment is better than a flat slope, but with the rear of the levee we have had constant trouble. The material on the water side is held up by the water, and only has a tendency to sink when the water falls, but on the back of the levee all the filtration or sepage has a tendency to slide down the particles of earth and flatten the slope.

So I have determined to recommend that all levees over ten feet high, built of earth alone, should have at least three to one for the rear or land slope, and I am satisfied with that slope for the front, for I have found in many of the old levees that were built with the five to one slope in front, have, by the *undertow* of the waves, assumed about three to one at the water line. When the levees are built entirely above the height of the waves and swells from steamboats, there is no need of the flat front slope to break their force; and the idea of water pressing *down* on such slopes to hold the levee to its place, as some people say, is absurd, for while water may *weigh* downward, its pressure, properly speaking, is lateral and upward, which to resist needs the mass of earth in the crown and rear slope, as already mentioned.

Where the land is very valuable and a decrease in the base of the levee is desired, it can be accomplished with much smaller slopes, but not with a less quantity of material or less cost in money. Slopes of one to one may stand on both front and rear if the material is properly rammed or stamped by animals in the construction, and by this means forcing two cubic yards into the natural space of one; and when levees are built with carts or scrapers the slopes can be materially changed or reduced. And another plan, which we

have lately begun to practice, of placing in the levee some impervious material by which the filtration or sepage may be prevented, must also enable us to reduce the crown and slopes. As said before, earth is not a "tie," but simply a "brace," and being heavier than water will resist its pressure foot for foot and yard for yard unless by saturation it loses its own frictional qualities and melts and sloughs away.

It is true that to take advantage of either plan to reduce the sections of the levees, will require constant watching that the work may be properly done; and many will prefer the sections of magnitude, that no negligence or inattention can injure, but this is not always practical, and the engineer must vary his plan and section to suit each special levee that he builds.

I have probably said enough about the cross-section of levees, and will now speak of the far more difficult problem: Their location.

A school boy can be taught by formula how to construct a levee, but in the location of it comes so many conflicting interests, so many collateral circumstances, so many opposing forces, that even the wisest and most experienced engineer is liable to be at fault.

To determine whether the bank is caving or making, may seem simple, and in large concave or convex bends, it is certainly evident. But levees are not always built in long, continuous lines, and the bank that caved last year in one part of a bend, may be a making bank this year, and that that made last year, cave this. But even after you determine that the bank is caving, the location of the curtain of your work depends upon many contingencies, the three most important of which are: the means at command; the height or cost of the work, and the value of the property to be turned out or protected. If your means are limited, your work must be small or close and dangerous. If the property be very valuable, it may be proper to risk your work, or even sacrifice it every few years to destroying the property to be protected, and if your levee is costly and the land cheap, sacrifice the property by all means and save your work.

These are the controlling influences in the locating of a local levee, when no regard is had for communities or general plans; and an individual either misled by hope or faith, or selfishness, will often endanger millions to save a single shade tree.

Under the present system there is a more comprehensive policy adopted, and the interests of the communities and the whole State are brought into the equation, and though some strictly local or individual interest has to be served, yet these are but as "tubs thrown to the whale," and the plan to save all is not abandoned.

My doctrine has been that every foot of land in Louisiana is the property of Louisiana, and the occupant has but a life lease upon it, to be transferred to his heirs, executors or assigns, as the case may be, when he dies or breaks, and that the annual products of the soil is the property of the children of Louisiana, and that it is her duty to protect her lands and develop her resources, and whenever a levee will protect or develop a sufficient amount of sugar, cotton, or commercial facilities, to counterbalance the risk or cost of the levee should it cave in after the crops have been gathered, I have always concluded that it was my duty to take some risks in the location. I have been fortunate in such locations, except in three instances, which were the Elton, the Wilson and the Kempe levees in Carroll and Tensas.

The speed of the cave at Elton could not have been anticipated, and two small works have been lost there, but they fully performed their object, as a large amount of cotton was protected by them The levee at Wilson's, in Tensas, was not expected to stand longer than three seasons, because there were not means enough to build a levee on a permanent line, and while it has protected nearly 40,000 bales of cotton in the three years, it has now caved in and must be rebuilt. The large and costly work at Kempe, in Tensas, will cave in the coming season, though built on the best location available, only three years ago. This has been occasioned by the formation of a large gravel bar in the middle of the river, which has shown a tendency to connect with the Mississippi or left bank, and thus throw the whole channel on the Louisiana or right bank.

A fine work built at Bondurant's in the same parish, which was threatened by a similar bar formation, has been rendered safe for many years by the channel attacking Bruinsburg, on the opposite side of the river; and thus with all the experience and wisdom that can be brought to bear mistakes are made, sometimes by loosening the levee, and as often by taking more valuable land than absolutely necessary. Neighbors always disagree as to the locations of levees,

and not one proprietor in a hundred but objects to the engineer going so far back, and not one neighbor in a hundred but who thinks the levee is not far enough back on the other man's land, and not one man in a thousand will agree that he lives on a caving bank, and many amusing anecdotes are told among the engineers of the quarrels between neighbors on this important subject, and the engineer should always take the responsibility and make a fair equation, as said before, between the means at command, the interest to be protected and the property to be destroyed.

Cause of Increase of Quantities in the Levees each Year.

To account for the increase in the quantities of levee work it must be known that the natural surface becomes lower or falls off very rapidly as you recede from the river bank, and all levees built in the rear of old levees are necessarily much higher than the previous ones, and when it remembered that each foot of additional height is placed at the *bottom* of the levee, with the increased base, one can see how fast the quantities multiply. A ten foot levee is more than three times as large as a five foot levee, even with the same slopes; but as the slopes are generally increased in proportion to the height of the levee on account of the longer time the water will stand against the base, the great additions are evident.

Very few of the original levees exceed five feet in height, as is evident from many of them still standing, but in the caving bends scarcely any are now lower than ten feet, while many reach eighteen and twenty feet in height, and are, therefore, not less than ten times the size of the original levees.

On the making banks it is seldom that the levees are thrown forward after once being built; but several cases of the kind will soon occur, the most noted of which will be the Bonnet Carre bend, above the crevasse, where it is proposed to build a new levee, near the river, where it can be built cheaper than to repair the old levee.

Another cause of the increase in the quantities of the levees, is the habit of doing most of the work in detached pieces, which necessitates long wings to throw the levees back to obtain material to build with, even when the banks are not caving, which is a large percentage on the total amount of earth used. To close the Bonnet Carre crevasse is a striking illustration of this fact; for there the

whole line is four thousand six hundred feet long, and the main curtain but one thousand six hundred and fifty feet, as will be seen on plate number five in this report.

Many persons think that the mouth of the river has been projected into the Gulf a sufficient distance to raise the surface or plane of the high water sufficiently to affect the levees, and others think that the building of the levees in Mississippi and Arkansas has concentrated the floods and produced a like effect, but neither of these causes have produced an appreciable effect as yet, and the high water plane has not changed during the history of levees in America, as can be easily demonstrated; and this apparent rise of the river plane is produced by the levees being built on lower ground, as before mentioned; and this constant increase in the existing quantities is produced by the same cause.

In conclusion I would repeat the substance of what I have just said; it is this:

The lands must be protected from overflow, while granting that cut-offs and outlets afford temporarily the relief their advocates claim, yet I think that neither plan gives permanent reduction of the plane of high water, and that either is far more expensive than levees.

I will advocate the protection of the banks wherever the good will compensate for the cost, and I most earnestly advocate the levee system as laid down in the book of Generals Humphreys and Abbot, and as about to be carried into effect by the Louisiana Levee Company under the present laws, for there is now a comprehensiveness of plans, a concentration of purpose, and a professional responsibility that will develop resources and means to accomplish this great good, and I believe that after another season's work such a thing as a crevasse will not be known in Louisiana, until another generation which has never seen the destruction of a crevasse shall have become careless or reckless in the care of the levees, and receive some bitter lessons to teach them the importance of eternal vigilance.